AN ASSESSMENT OF FREEZE-BRAND AND PIT-TAG RECOVERY DATA FOR JUVENILE SALMONIDS AT MCNARY DAR

Annual Report of Research, 1988

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Project 87-130
Agreement DE-Al79-87-BP34269

February 1990

ABSTRACT

This study evaluated mark recovery data from PIT-tagged and freeze-branded river-run yearling and subyearling chinook salmon (Oncorhynchus tshawytscha), sockeye salmon (O. nerka), and steelhead (0. mykiss) at McNary Dam in 1988. Double-marked (PIT-tagged and freeze-branded) juvenile salmonids were released within the McNary Dam collection system upstream from the PIT-tag detectors and brand sampling system. Results indicate that brands were recovered in smaller proportions than PIT tags and the variability of brand data was considerable. Most of the error associated with brands was attributable to human error inherent in brand detection and interpretation.

CONTENTS

INTRODUCTION

Investigations at McNary Dam (Columbia River Mile 292) suggested that PIT-tagged juvenile salmonids were recovered in significantly higher proportions than those which were freeze-branded (Prentice et al. 1987). In 1987, research was conducted to assess the extent and nature of the differential recovery proportions in yearling and subyearling chinook (Oncorhynchus tshawytscha and sockeye salmon (O. nerka), and steelhead (O. mykiss). from 1987 indicated that PIT tags were consistently recovered in significantly higher proportions than freeze brands regardless of species or stock (McCutcheon and Giorgi 1989). Furthermore, PIT tags provided more precise recovery data. The discrepancy in mark recovery proportions suggested a bias may be associated with the recovery of brand data. However, it was not possible to directly identify the source of the error. The inaccuracy could have been associated with the sampling mechanism or the brand reading and transcription process.

In 1988, the research objectives were to determine if juvenile salmonids are sampled from the separator at the rate established on the sample timer mechanism, and to what extent brand reading and transcription are a source of error.

METHODS AND MATERIALS

Fish used in this study were acquired from the juvenile collection system of McNary Dam (Fig. 1). Details regarding dates, sizes, numbers, and marks used in each test are summarized in Appendix A. Fish were selected from the population in the sampling tank at the fish handling facility using the protocol employed by the freeze-branding teams at that site.[1]

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[1] Fish were rejected prior to marking (tagging and freeze branding) if they were diseased, injured, descaled, previously marked, or precocious males, as well as steelhead less than 145 mm.

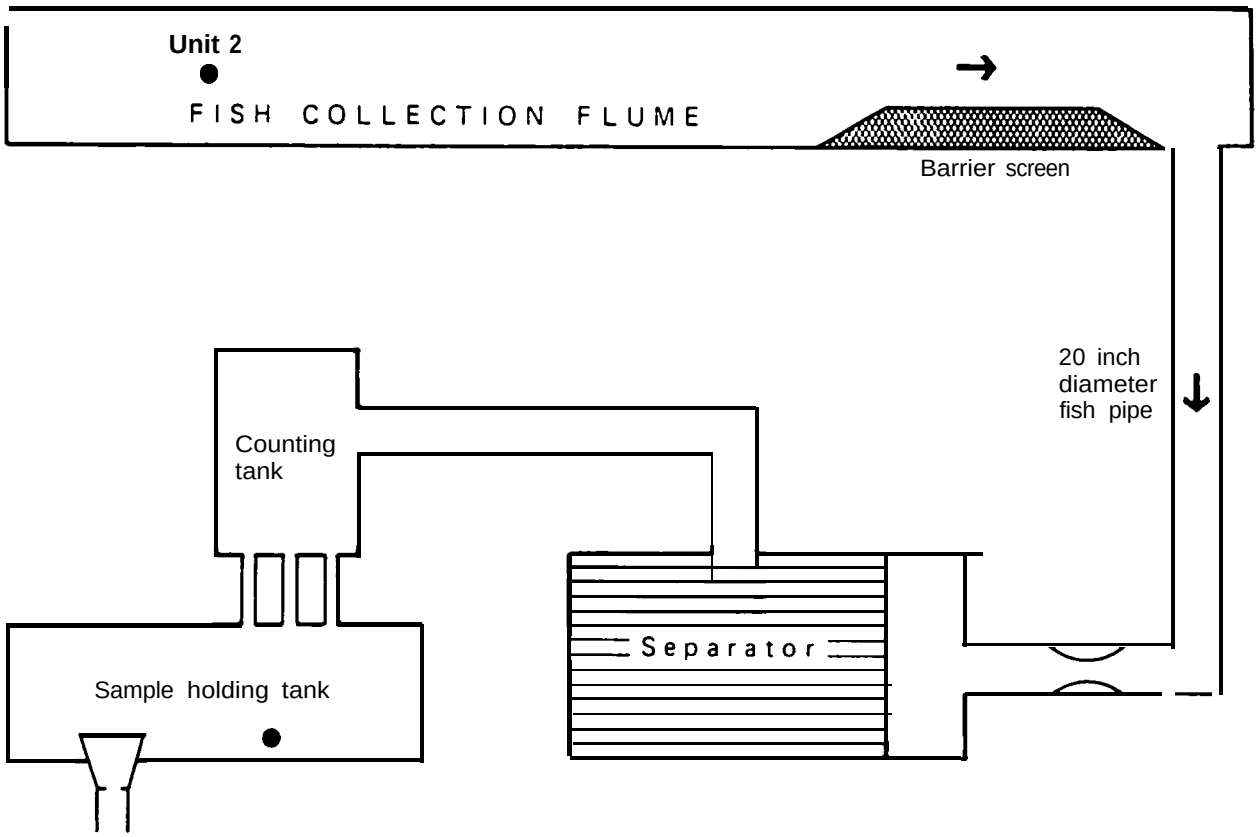

Figure l.-Schematic view of fingerling collection system at McNary Dam (fish release locations are marked with a black circle).

Freeze branding was conducted using methods described by Mighell (1969). PIT-tagging was conducted using methods described by Prentice et al. (1987).

Two methods were used in 1988 to evaluate the McNary Dam collection system: 1) double-marked fish bearing a brand and a PIT tag were released into the collection flume (Fig. 1) and 2) fish bearing only brands were released directly into the sample tank. Marked individuals were recovered in the fish handling facility. PIT tags were detected by a monitor system fitted to the entrance flume in the facility. Brands were interpreted and recorded by the smolt monitoring staff on site.

Bypass System Releases

At McNary Dam, the daily fish sample is used for a variety of experimental and management purposes. The daily rate at which fish are sampled from the bypass population varies depending on the needs of users and the total number of fish in the system (the sample tank can be overloaded). Each day, the Corps of Engineers (COE), biologist estimated the sample rate to be used for the next day's sample. For flume releases, group sizes varied according to the expected sample rate and were adjusted so that a minimum of 60 fish would be recovered in the sampling facility.

Prior to release, marked fish were held for 3 days in 720-liter portable holding containers (Swan[2]) equipped with a flow-through water supply and an auxiliary air supply. Mortalities were removed and recorded daily. These were later deducted from the number originally marked. One hour prior to release a random sample of 30 to 110 fish was examined and graded for brand legibility using criteria described by the Smolt Monitoring Program (FPC 1987). To estimate the effective number of legible brands in each group, fish brands categorized as Class 3 (illegible) or Class 5 (not visible) were subtracted from each release group.

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[2] George Swan, National Marine Fisheries Service, Building 900 Big Pasco Industrial Park, Pasco, WA 99301. Pers. commun. (manuscript in progress), January 1989.

All groups of fish were transported in the holding containers to the turbine intake deck of McNary Dam and released via a 7.6-cm diameter hose into the bypass flume at Turbine Unit 2. Releases were made within the hour after the sample timer was set. Sample rates at the fish holding facility were changed at noon each day.

PIT tags were first detected as fish exited the separator (Fig. 2). All fish exiting the separator were interrogated. An additional tag detector was fitted on the entrance port to the sampling building. All fish within the timed subsample moved through this detector. Brands in the timed subsample were read and recorded in the sampling building by Smolt Monitoring Program personnel. The estimated number of a particular brand in the bypass population (often referred to as the "expanded" estimate) was calculated as the ratio of the number of brands observed in the sample to the proportion of time the sample was extracted.

PIT-tag recovery data specified the date and time detected. Recovery data for brands were pooled over a 24-hour period (noon to noon). For comparative purposes, daily PIT-tag recovery data were adjusted to the same time frame. Only recovery data observed during the first sample day after release were analyzed. This ensured that all fish from a particular release were subjected to the same daily sample rates, since some fish require more than 24 hours to pass from the flume through the separator.

Recovery proportions of tags and brands were compared using chi-square tests.

Sample Tank Releases

To assess the extent of brand reading error, some groups of fish were marked with a freeze brand only and released directly into the sample tank. A variety of marking tool shapes, sixes, and rotations were used. Release groups ranged in numbers from 57 to 102. All fish were marked by the same experienced fish marker.

Branded fish were held for 3 days in 120~liter holding containers prior to release. At release, fish were enumerated, examined for brand legibility, and released directly

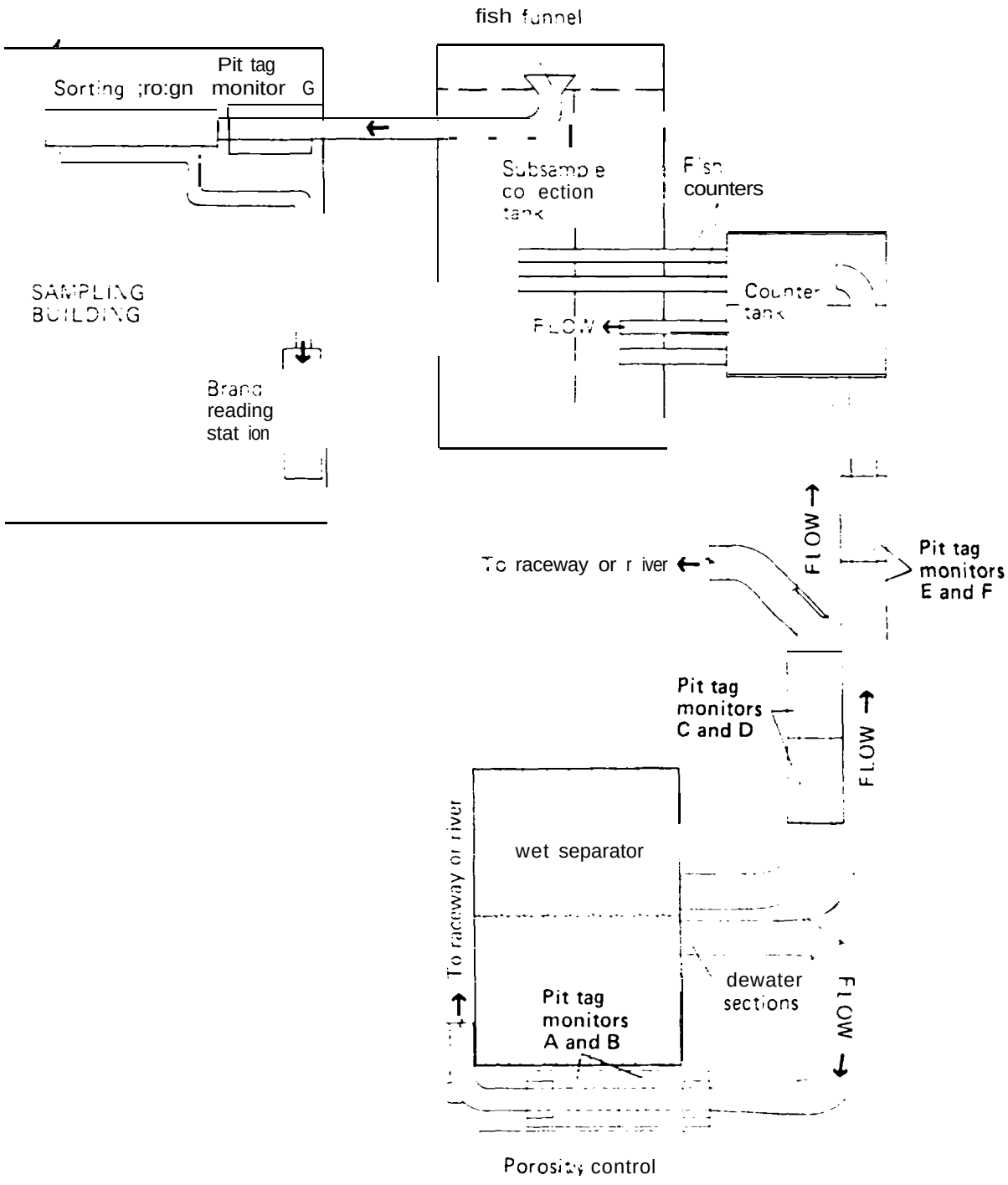

Figure 2.--Detailed overview of the McNary Dam fingerling sampling system.

into the sample tank.[1] Releases were made after the daily sample was taken so the fish would be examined by the brand reading crew on the fourth day after marking.

RESULTS

Recovery Proportions

Four groups (total = 2,587) of double-marked yearling chinook salmon were released into the bypass system. From those, 2,500 (96.6%) tags were detected leaving the separator. Tag recovery proportions displayed little intergroup variability, ranging from 0.960 to 0.979 (Table 1, Fig. 3). Brand release numbers were adjusted for legibility (see Appendix Table B1). Using brand data adjusted for legibility, significantly fewer ($P < 0.001$) of the brands were estimated as recovered than observed for PIT tags. Only 83% of the brands were estimated as recovered. Furthermore, variability in recovery proportions among groups was pronounced, ranging from 0.53 to 1.06 (Table 1, Fig. 3).

It should be noted that during the 24-hour recovery period for the 10 May release, the timer setting was changed on four occasions. The PIT-tag recovery proportion was 0.98, the highest observed (Table 1), whereas brands were recovered in their lowest proportion (0.53) (Table 1).

Three groups (total = 3,273) of double-marked subyearling chinook salmon were released into the bypass system. A total of 3,056 (93.4%) tags were detected exiting the separator. Intergroup recovery proportions of PIT tags displayed little variability, ranging from 0.92 to 0.96 (Table 1, Fig. 3). Overall, slightly fewer brands than tags were recovered. Adjusted for legibility, 0.92 were estimated as recovered. However,

[1] Fish from the first and second group of yearling chinook salmon were not examined for brand legibility prior to release.

Table 1.--Mark release and recovery data, 1988. Recovery data are the total over the entire mark-recovery period. Brand recoveries are expanded by the daily timer setting. All fish were both branded and tagged. Tag recoveries were those detected exiting the separator. Brand data are both adjusted and unadjusted for brand legibility at time of release. See Appendix B Table 1 for details regarding the estimate of the number of legible brands at release.

Species	Release date	Number released	Total number recovered		Recovery proportions		
			PIT tag	Brand	PIT tags	Brands not adjusted	Brands adjusted for legibility
Chinook							
Yearling3	29 Apr	561	542	470	0.966	0.867	0.892
	10 May	620	607	217'	0.979	0.357	0.525
	24 May	805	773	619	0.960	0.769	1.046
	29 May	601	578	458	0.962	0.762	0.792
Subyearlings	10 Jul	1,194	1,093	1,080	0.915	0.905	0.922
	16 Jul	1,211	1,158	1,319	0.956	1.089	1.089
	21 Jul	868	805	571	0.927	0.658	0.665
Steelhead	6 May	612	585	404	0.956	0.660	0.825
	16 May	644	606	364	0.941	0.565	0.721
	23 May	853	830	779	0.973	0.913	0.930
Sockeye	1 Jun	145	122	63	0.841	0.434	0.434

[a]During this recovery period, the timer was adjusted four times in 24 hours. The sample rate indicated is a weighted average calculated by the Fish Passage Center (FPC).

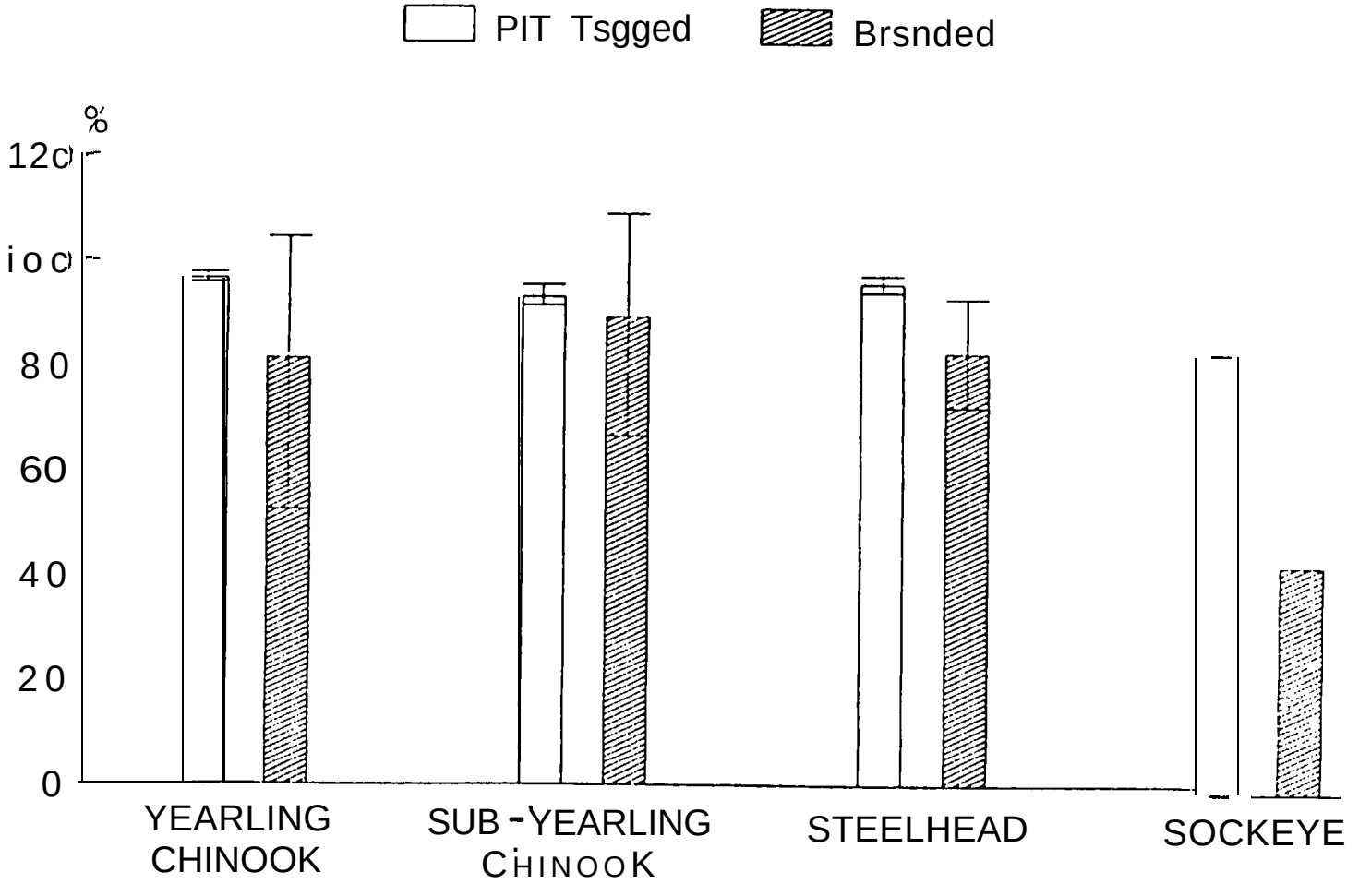

Figure 3.--Mark-recovery percentages (means) from double-marked (branded and PIT-tagged) juvenile salmonids released into the McNary Dam bypass flume and recovered at the fmgerling sampling system, 1988. Brand data were adjusted for legibility. Vertical lines indicate the range for three release groups.

the variability in the recovery proportions among groups was considerable, ranging from 0.67 to 1.09 (Table 1, Fig.3).

A total of 2,109 steelhead were double-marked, subdivided into three groups and released into the bypass system. A total of 2,021 (95.6%) were detected exiting the separator. Intergroup recovery proportions of the tags exhibited little variability, ranging from 0.94 to 0.97 (Table 1, Fig. 3). Adjusted for legibility, only 83% of the brands were estimated to be recovered. Variability in intergroup recovery proportions was considerable, ranging from 0.72 to 0.93 (Table 1, Fig. 3).

Due to limited fish availability, only one group of marked sockeye salmon (n = 145) was released into the bypass system. Eighty-four percent of the tags were detected exiting the separator. Only 43.5% (n=63), of the brands were recovered (Table 1, Fig. 3).

Timer Evaluation

In this series of evaluations we tested the hypothesis that juvenile salmonids exiting the separator were sampled in the proportion specified on the timer. Using PIT tags detected leaving the separator and those detected in the sample, we employed the **chi-square** statistic and tested each group separately (Table 2) (see Appendix B2).

Inspection of the recovery data indicated that fish tended to be sampled at somewhat less than the nominal sample rats (Table 2). However, in no case was the proportion of fish extracted significantly different than the timer setting, but some probabilities did approach 0.05 (Table 2). Further evidence that the sample gate may tend to undersample was apparent when data were analyzed using Fisher's combined probability test (Fisher 1944). In that comparison, the proportion of fish from all tests that were diverted into the sample was significantly less than the overall prescribed timer setting (&i-square = 35.34, d.f. = 22, $0.025 \leq P \leq 0.05$). Thus, the observed discrepancies in tag and brand recovery proportions appears to be in part associated with the sampler mechanism.

Table 2.--Results of chi-square (df = 1) to test the hypothesis that the proportion of sampled yearling and subyearling chinook and sockeye salmon and steelhead was the same as the proportion of time the sample was extracted. The probability (P) associated with each chi-square test is reported.

Species	Release date	Proportion of time scheduled	Proportion of tags leaving separator detected in sample	Chi-square	P
Chinook					
yearlings	29 Apr	0.100	0.096	0.094	0.757
	10 May[a]	0.088	0.070	2.319	0.129
	24 May	0.200	0.179	1.923	0.165
	27 May	0.150	0.121	3.586	0.059
subyearlings	10 Jul	0.050	0.050	0.002	0.860
	16 Jul	0.050	0.056	0.762	0.384
	21 Jul	0.070	0.054	3.096	0.079
Steelhead	6 May	0.100	0.076	3.495	0.061
	16 May	0.100	0.078	3.161	0.075
	23 May	0.150	0.164	1.186	0.276
Sockeye	1 Jun	0.080	0.066	0.345	0.555

[a] On this date the timer setting was changed on four separate occasions. The proportion of time sampled is the weighted mean of those settings.

Brand Interpretation

Discrepancies between PIT-tag and brand-recovery proportions are to a great extent associated with error inherent in the brand reading process. Inspection of recovery data from branded fish, released directly into the sample tank, indicated high variability in brand interpretation (Tables 3-6).

Steelhead and sockeye salmon displayed the most variability (Tables 3 and 4). Generally, brands were recovered in low proportions. In several instances, no brands were observed. The recovery proportions for branded steelhead and sockeye salmon ranged from 0.0 to 1.0 (mean = 0.68) and 0.0 to 0.94 (mean = O-48), respectively.

Brand recovery data from subyearling chinook salmon were consistently higher than for any other species (Table 5). Recovery proportions ranged from 0.84 to 1.24 for 11 marked groups. The mean proportion recovered was 1.01 for all groups combined.

Brand recovery data for yearling chinook salmon are not as clear. Prior to 23 April, freeze-branded groups were not graded for legibility. Recovery proportions (adjusted for legibility) for two groups released 23 April were 0.93 and 1.04 (Table 6). Recovery proportions on 18 and 19 April were very low and variable, recognizing that the release numbers were not adjusted for legibility.

There are two explanations for recovery proportions greater than 1.0: 1) brands graded as illegible at release were legible to brand readers in the sample room, or 2) a similar brand (usually a rotation or body position designation) was mistakenly reported.

Table 3.--Recovery data from freeze-branded steelhead released directly into the sample tank at McNary Dam, 1988. Fish were held for 3 days after branding, then released. Brands were processed 24 hours following release. Only brands which were legible were released into the sample tank.

Release date	Brand	Number released	Number recovered	Proportion recovered
18 May	RA PP1	18	14	0.78
	LA PP1	3	0	0.00
	RD PP1	15	0	0.00
	LD PP1	21	16	0.76
	RD PI2	17	17	1.00
	LD PI2	9	9	1.00
	Totals	83	56	0.68

Table 4.--Recovery data from freeze-branded sockeye salmon released directly into the sample tank at McNary Dam, 1988. Fish were held for 3 days after branding, then released. Brands were processed 24 hours following release. Only brands which were legible were released into the sample tank.

Release date	Brand	Number released	Number recovered	Proportion recovered
14 May	RA 7Tl	11	6	0.55
	LA 7Tl	10	9	0.90
	RD 7Tl	9	4	0.94
	LD 7T2	8	5	0.63
	RA Fl	13	8	0.62
	IA Fl	16	7	0.44
	LD F3	0	1[a]	0.00
		67	41	0.61
12 June	LA F3	13	12	0.92
	RA F3	15	0	0.00
	RD Pl1	14	0	0.00
	LD PI1	15	12	0.80
	LA Fl	O	1'	0.00
		67	25	0.37

[a]Fish bearing this brand were not released.

Table 5.--Recovery data from freeze branded sub-yearling chinook salmon released directly into the sample tank at McNary Dam,1988. Fish were held for 3 days after branding, then released. Bands were processed 24 hours following release.

Release date	Brand	Number released	Number legible	Number recovered	Proportion recovered of legible brands
11 Jul	LA F3	34	34	35	1.03
	LD F3	34	32	32	1.00
	RD F3	34	33	34	1.03
		102	99	101	1.03
15 Jul	RA PP1	25	25	21	0.84
	RD PP1	25	25	27	1.08
	LA PP2	23	23	25	1.09
	LD PP2	25	16	22	1.24
		98	89	95	1.15
23 Jul	RA 7T1	20	20	22	1.10
	RD 7T1	23	23	22	0.96
	LA 7T3	22	22	19	0.86
	LD 7T3	24	24	21	0.88
		89	89	04	0.94

Table 6.--Recovery data from freeze-branded yearling chinook salmon released directly into the sample tank at McNary Dam, 1988. Fish were held for 3 days after branding, then released. Brands were processed 24 hours following release.

Release date	Brand	Number released	Number legible	Number recovered	Recovery proportions adjusted for brand legibility
18 Apr	LA PPl	13	-0	12	0.92"
	LD PPl	13	-a	1	0.08[a]
	RA PP2	17	-[a]	4[b]	0.18"
	RD PP2	17	-[a]	0	0.0"
	LA PP2	0	0	1	-[a]
		60		18	
19 Apr	LA PPl	16	-[a]	8	0.500"
	LD PPl	18	-[a]	4	0.220[a]
	LA PP2	14	-[a]	7	0.500"
	LD PP2	12	-[a]	4	0.330"
		60		23	
23 Apr	RA PPl	28	28	26	0.929
	LA PP2	29	25	26	1.040
	LA PP1	0	0	1	-[c]
	RA PP2	0	0	1	-c
		57	53	54	

[a] Brand legibility was not evaluated.
[b] One fish was observed on second day after release.
[c] Fish bearing this brand were not released.

DISCUSSION

Discrepancies in recovery proportions of PIT tags and freeze brands as observed at McNary Dam were first reported by Prentice et al. (1987). In that investigation, brands were recovered in lower proportions. However, it was not certain that brands had sufficient time to develop prior to the branded fish being intercepted at McNary Dam. In 1987 and 1988, we took measures to alleviate this uncertainty. In the present study, all branded fish were held at least 3 days prior to release into the bypass system or sample tank, and none were available for visual inspection by brand readers until the fourth day. Furthermore, all except one group of branded fish were graded for brand legibility just prior to release, and brand recovery proportions were adjusted according to the legibility factor for each group. Thus, insufficient brand development which was a concern in some earlier studies was determined not to be an important factor in our investigation.

Another uncertainty associated with earlier evaluations at McNary Dam was that the marking procedures (branding vs PIT tagging) may result in differential mortality or impaired behavior which could influence the recovery proportions at the dam. The use of double-marked fish in this year's investigation eliminated that concern, and brands were still recovered in lower proportions, particularly for steelhead and yearling chinook and sockeye salmon. Brands appear to show better on subyearling chinook salmon; brands and PIT tags were recovered in nearly the same proportion; however, the variability associated with the brands was considerable (Fig. 3).

Observations in 1987 (McCutcheon and Giorgi 1989) suggested that the sampling mechanism, which is activated by a timer switch, may not be extracting fish from the bypass population in the same proportion as prescribed by the timer. Results indicate that over a 24-hour period the sample gate may tend to slightly undersample the bypass population (Table 2).

The 1988 study suggested that the poor and variable recovery proportions of brands relative to PIT tags was primarily attributable to human error associated with brand identification and interpretation. In several instances brands that were legible and placed directly in the sample tank were not detected by the brand readers. This was particularly evident for steelhead and sockeye and yearling chinook salmon (Tables 3, 4. and 6). Another error occurs when brands are read but misclassified as another mark. The result is essentially two errors since data are removed from one group and added to the observations in another group. Examples of this are apparent in Tables 4 and 6, for sockeye and yearling chinook salmon.

The 2-year mark-recovery evaluation at McNary Dam indicated that brands produce more variable data than PIT tags, and, for steelhead and sockeye and yearling chinook salmon, brands were recovered in significantly lower proportions. Branded subyearling chinook salmon were generally recovered in the same proportion as PIT-tagged fish, but the brand data were variable. These findings have far reaching implications to mark-recapture investigations which use facilities at McNary Dam and perhaps other sites. There is considerable subjectivity associated with the brand interpretation process. One group of people grade brands prior to release whereas a different group inspects for marks at recapture sites. Apart from the human subjectivity, effects such as ambient lighting conditions, melanophore responses in anesthetized fish and guanine deposition during smolt development compound the problem. The use of PIT tags circumvents these difficulties and provides more accurate and precise information. For this reason, NMFS has used the PIT tag for investigations which estimate juvenile survival, collection efficiency, and travel time. In some situations, freeze brands provide adequate information. Therefore, we recommend that the objectives of each study be examined carefully, and technical committees, and the choice of mark or tag be given ample assessment.

CONCLUSIONS

1) The low and variable recovery proportions of brands relative to PIT tags is primarily attributable to human subjectivity associated with brand grading, detection, and interpretation.
2) The timer-regulated sample gate tends to slightly undersample fish in the collection system; however, this does not appear to be an important factor affecting the low and variable recovery of branded fish.
3) Brands and PIT tags have utility in mark-recapture studies, and technical committees and funding agencies involved with such programs should determine which mark will provide the most satisfactory data for each particular study.

ACKNOWLEDGMENTS

Support for this research came from the region's electrical ratepayers through the Bonneville Power Administration.

Special thanks are given to Brad Ebe and Sue Knapp of the U.S. Army Corps of Engineers' biological staff at McNary Dam for their efforts in coordinating the marking and releasing of the various test groups.

In addition, we offer our appreciation to the personnel of the Fish Passage Center, Washington Department of Fisheries, and the National Marine Fisheries Service fish sampling staff at McNary Dam for their assistance in this study.

LITERATURE CITED

Fish Passage Center (FPC).
1987. Smolt monitoring program annual report 1986. Bonneville Power Administration, Project 86-60. 133 p. + Appendixes. Fish Passage Center, 825 NE 20th Ave., Suite 336, Portland, OR 97232.

Fisher, R. A.
1944. Statistical methods for research workers. 9t.h edition. Oliver and Boyd Ltd., London. 350 p.

Giorgi, A. E., G. Swan, W. S. Zaugg, T. Colve. and T. Barila.
1988. Smolt development in yearling chinook salmor Oncorhynchus tshawytscha, and susceptibility to bypass systems at hydroelectric dams. North Amer. J. Fish. Management 8(1):26-29.

Matthews, G. M., D. L. Park, J. R. Harmon, and C. S. McCutcheon.
1987. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1986. NOAA, NMFS, Northwest and Alaska Fisheries Center, Seattle, Washington. 34 p. + Appendixes (Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034).

McCutcheon, C. S., and A. E. Giorgi.
1989. An assessment of freeze brand and PIT tag recovery data at McNary Dam, 1987. NOAA, NMFS, Northwest Fisheries Center, Seattle. Washington. 23 p. + Appendixes (Report to Bonneville Power Administration, Contract DE-AI79-87BP34269, Project 87-130).

Mighell, J. L.
1969. Rapid cold-branding of salmon and trout with liquid nitrogen. J. Fish. Res. Board Can. 26:2765-2769.

Prentice, E. F., D. L. Park, T. A. Flagg, and C. S. McCutcheon.
1985. A study to determine the biological feasibility of a new fish tagging system, 1985-1986. NOAA, NMFS, Northwest and Alaska Fisheries Center, Seattle, Washington. 79 p. + Appendixes (Report to Bonneville Power Administration, Contract DE-AI79-84BP11982, Project 83-319).

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon.
1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. (Report to Bonneville Power Administration, Contract DE-AI79-84BP11982, Project 83-319).

Raymond, H. L.
1974. Marking fish and invertebrates. I. State of the art of fish branding. Mar. Fish. Rev. 36(7): 1-9.

APPENDIX A

Summaries of PIT Tagging and Freeze Branding

Appendix Table Al.--Summary of PIT tagging and freeze branding yearling chinook salmon at McNary Dam, 1988.

Number of groups tagged : 4
PIT tag injection method: Auto-tagger
Length taken on all fish
Weight taken on 10% of groups 1, 2, and 3.

Group 1:

Tag Date	: 26 April
Release Date	: 29 April
Number Marked	: 588
Number Released	: 561
Weight	: min.= 5.2 / max. =108.1/ ave.=44.2g
Length	: min.=109 / max. =249 / ave.=169mm
Associated brand	: RAP/1

Group 2:

Tag Date	6 May
Release Date	: 10 May
Number Marked	: 631
Number Released	: 620
Weight	: min.= 9.8 / max. =90.7 / ave.=33.4g
Length	: min.=105 / max.=225 / ave.=149mm
Associated brand	: LD7T3 (229) AND LD7Tl (326)

Group 3:

Tag Date	: 20 May
Release Date	: 24 May
Number Marked	: 865
Number Released	: 805
Weight	: min.=14.4 / max.=81.9 / ave.=40.0g
Length	: min.= 99 / max.=228 / ave.=157mm
Associated brand	: LA F4

Group 4:

Tag Date	: 25 May
Release Date	: 2 9 May
Number Marked	: 614
number Released	: 601
weight	: weight not taken
Length	: min.=109 / ma:-:.=228 / ave .=157mm
Associated brand	: LA7T3

Appendix Table A2.--Summary of PIT tagging and freeze branding sub-yearling chinook salmon at McNary Dam, 1988.

Number of groups tagged : 3
PIT tag injection method: Auto-tagger
Length taken on all fish
Weight taken on 10%

Group 1:

Tag Date	: 7 July
Release Date	: 10 July
Number Marked	: 1223
Number Released	: 1194
Weight	: min.= 1.1 / max.=18.9 / ave.=10.2g
Length	: min.= 78 / max.=157 / ave.=97 mm
Associated brand	: RA Fl

Group 2:

Tag Date	: 13 July
Release Date	: 16 July
Number Marked	: 1241
Number Released	: 1211
Weight	: min.= 3.0 / max.=35.2 / ave.=11.8g
Length	: min.= 80 / max.=148 / ave.=lOOmm
Associated brand	: LAPP2

Group 3:

Tag Date	: 18 July
Release Date	: 21 July
Number Marked	: 897
Number Released	: 868
Weight	: min.= 6.5 / max.=27.8 / ave.=11.8g
Length	: min.= 79 / max.=147 / ave.=102mm
Associated brand	: RD7T3

Appendix Table A3. --Summary of PIT tagging and freeze branding steelhead at McNary Dam, 1988.

Number of groups tagged : 3
PIT tag injection method: Auto-tagger
Length taken on all fish
Weight taken on 10%

Group 1:

Tag Date	: 3 May
Release Date	: 6 May
Number Marked	: 632
Number Released	: 612
Weight	: min.=21.4 / max.=179.5/ ave.=77.6g
Length	: min.=137 / max.=286 / ave .=205mm
Associated brand	: LA F3

Group 2:

Tag Date	: 12 May
Release Date	: 16 May
Number Marked	: 862
Number Released	: 644
Weight	: min.=24.5 / max.=184.8/ ave.=72.9g
Length	: min.=126 / max.=279 / ave.=2llmm
Associated brand	: LAPP2
Release Remark	: Water was turned off to the fish holding facility during barge loading causing severe stress.

Group 3:

Tag Date	: 19 May
Release Date	: 23 May
Number Marked	: 862
Number Released	: 853
Weight	: min.=12.1 / max.=132.6/ ave.=54.2g
Length	: min.=139 / max.=276 / ave.=199mm
Associated brand	: RA F2

Appendix Table A4.--Summary of PIT tagging and freeze branding sockeye salmon at McNary Dam, 1988.

Number of groups tagged : 1
PIT tag injection method: Auto-tagger
Length taken on all fish
Weight taken on 10%

Group 1:

Tag Date	: 27 May
Release Date	: 6 June
Number Marked	: 165
Number Released	: 146
Weight	: min.= 7.9 / max.=58.1 / ave.=16.lg
Length	: min.=92 / max.=177 / ave.=118mm
Associated brand	: RA F2

APPENDIX B

Summaries of Recovery Data

Appendix Table Bl.--Brand recovery data adjusted for legibility. Recovery data are the total over the entire mark-recovery period. The legibility factor was estimated from a random subsample of fish which was examined just prior to release, 3 days following marking.

Species	Release date	Number released	Percent legible	Number released, adjusted for legibility	Estimated number collected	Recovery proportions adjusted for legibility
Chinook						
Yearlings	29 Apr	561	93.9	527	470	0.89
	10 May	620	66.6	413	217"	0.53
	24 MAY	805	73.5	592	619	1.05
	29 May	601	100.0	601	458	0.79
Subyearlings	10 Jul	1,194	98.1	1,171	1,080	0.92
	16 Jul	1,211	100.0	1,211	1,319	1.09
	21 Jul	868	99.0	859	571	0.67
Steelhead	6 MAY	612	80.0	490	404	0.83
	16 MAY	644	78.4	505	364	0.72
	23 May	853	98.2	838	779	0.93
Sockeye	1 Jun	145	100.0	145	63	0.43

[a] During this recovery period, the timer was adjusted four times in 24 hours. The sample rate indicated is a weighted average calculated by the FPC.

Appendix Table B2.-Comparison between the proportion of time the sample gate was open during the 24hour period following release, and the proportions of PIT-tagged fish observed and branded fish estimated in the sample.

Species	Date	Number PIT tags detected within 24 hour of release		Erand		Proportion sampled		Proportion of time sampled
		System	Sample	Estimated as legible in the system	Observed in sample	PIT tag	Erand	
Chincok								
Yearlings	29 Apr	521	50		5	0.10	0.09	0.10
	10 May'	597	42		19	0.07	0.05	0.09
	24 May	751	135	552	119	0.18	0.22	0.20
	29 May	560	68	560	68	0.12		0.15
Subyearlings	10 Jul	1,073	54	1,053	53	0.0	.0	0.05
	16 Jul	1,132	63	1,132	65	3.06	0.06	0.05
	21 Jul	779	42	771	40	3.05	0.05	0.07
Steelhead	6 May	529	40	423	35	0.08	0.08	0.10
	16 May	567	44	445	35	0.08	0.08	0.10
	23 May	800	131	780	116	0.16	0.15	0.15
Sockeye	1 Jun	122	8	122	.5	0.07	0.04	0.08

• During this recovery period, the timer was adjusted four times in 24 hours. The sample rate indicated is a weighted average calculated by the FPC.